NAVAL HEALTH RESEARCH CENTER

PRELIMINARY EVALUATION OF SELECTED TELECOMMUNICATIONS TECHNOLOGIES FOR MEDICAL CARE ABOARD NAVY SHIPS

E. D. Gauker

W. M. Pugh

D. M. Pearsall

Report No. 95-32

NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CALIFORNIA 92186 – 5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

PRELIMINARY EVALUATION OF SELECTED TELECOMMUNICATIONS TECHNOLOGIES FOR MEDICAL CARE ABOARD NAVY SHIPS

Eleanor D. Gauker

William M. Pugh

Dianna M. Pearsall

Naval Health Research Center
Medical Information Systems and
Operations Research Department
P.O. Box 85122
San Diego CA 92186-5122

Technical Report 95-32 was supported by the Naval Medical Research and Development Command, Bethesda, MD, Department of the Navy. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government. Approved for public release, distribution unlimited.

EXECUTIVE SUMMARY

Problem

Recently, a wide range of information technologies has become available for communicating, processing, and integrating information. These technologies may have medical benefit for the crews of Navy ships because they may be used to exchange information with medical experts, thereby improving diagnostics and treatment decisions. However, it is unclear which of the available technologies may yield the greatest benefit.

Objective

The present study demonstrates a methodology for evaluating relative value of telecommunication technologies for making diagnosis and treatment decisions in Navy shipboard environments.

Approach

Fifteen technologies were rated on a 5-point Likert scale by 25 Independent Duty Hospital Corpsmen (IDCs) with experience aboard Navy surface ships. The IDCs rated the utility of the technologies with respect to 28 patient conditions. Each IDC was asked to complete 57 items, of which 25 referred to routine diagnostic decisions, 7 involved acute diagnostic situations, and 25 concerned treatment decisions. Intraclass correlations were computed for each question to determine the degree of agreement among raters.

Results

Four patient conditions had reliable ratings for both acute diagnostic and treatment decisions, six other patient conditions showed acceptable reliability for treatment decisions, and three conditions were rated reliably for routine diagnostic decisions. Although complex technologies, such as the transmission of x-ray images, were rated as beneficial for diagnosing and treating some disorders (e.g., sprains and strains) it was found that fax machines and e-mail were more beneficial overall. The analysis showed that those technologies rated most beneficial for diagnosis also tended to be most beneficial for treatment.

Conclusions

This study has demonstrated a method for ranking available technologies in terms of relative perceived benefit. However, the decision to implement this capability also should take into consideration issues such as command and control. With careful planning, appropriate personnel training, and appropriate testing and evaluation procedures, Navy telemedicine can be an effective tool, providing health-care to patients as well as consultation and education opportunities to health-care providers.

PRELIMINARY EVALUATION
OF SELECTED TELECOMMUNICATIONS TECHNOLOGIES
FOR MEDICAL CARE ABOARD NAVY SHIPS

The earliest use of telecommunication technology applications in medicine, or telemedicine, occurred in 1959, when two-way interactive television communication (IATV) was used for telepsychiatry consults.[1] About the same time, the rudiments of the TV health network were begun.[2] Several projects during the 1970s and 1980s focused on providing health services to remote populations. One of these, the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project, was sponsored by NASA to provide services to the Papago Indians in Arizona.[3] Another linked the Sioux Indians in Canada with doctors in Toronto.[4,5] These early projects used black-and-white TV along with telephones.[6]

The medical utility of advanced telecommunications capability in the management of catastrophic situations was demonstrated following the earthquake in Armenia in 1988. At that time, the Spacebridge project, a joint venture between the United States and Russia, used land lines, satellites, and two earth stations that linked four U.S. hospitals with NASA headquarters and, subsequently, Armenia. The transmissions were one-way color video, two-way voice, and two-way fax.[7] During the famine in late 1992, U.S. Army physicians in Mogadishu, Somalia, were linked by satellite hookup to a CONUS hospital.[8]

In addition to applications during mass casualty situations, the military can benefit from applications that focus on providing medical services to remote populations because troops often are deployed to areas far from sophisticated medical treatment facilities. The Navy, in particular, can utilize telecommunication technology on deployed ships, which are staffed by Independent Duty Hospital Corpsmen (IDCs). A 1984 study[9] examined the structure of shipboard medical departments and the process of health-care delivery at sea, where injuries and illnesses may require medical evacuation (medevac) either to a ship in the group with medical facilities or to a land-based treatment facility. Medevacs are costly and potentially dangerous to the patient, and they also interfere with the mission of the ship. In 28% of the cases surveyed in this study, there was a significant probability that the evacuation could have been avoided if telecommunication capabilities, such as the Navy's Remote Medical Diagnosis System (RMDS),[10] had been deployed.

The essential benefit of telemedicine is that it transcends geography. Therefore, patients in remote areas can receive medical consultation, second opinions, and other services electronically that might otherwise be impossible. Providers also benefit from electronic diagnostic and educational tools and interactive consultations. The cost of telecommunication can be expressed in "bandwidth," which is the carrying capacity needed to transmit a given amount of information within a fixed period of time. There are many ways to relay medical data and many ways to use the data, and although telemedicine is frequently described in terms of IATV, various medical situations have different requirements. The most complex system, the two-way uncompressed video, for example, requires 1,300 times more bandwidth than the simplest system, the telephone.[11] Therefore, it is important to match the technology to the application to achieve the most economical telemedicine interaction.

The definition of such telecommunications applications technologies, or telemedicine, has evolved along with rapid advances in technology. A 1992 definition describes *"telecommunication that connects a patient and a health-care provider through live, two-way audio, two-way video transmission across distances that permits effective diagnosis, treatment, and other health-care activities."*[12] By 1994, telemedicine was becoming more widely recognized as a field of endeavor, and Donald A.B. Lindberg, M.D., the director of the National Library of Medicine, in testimony before the House Science, Space and Technology Committee Subcommittee on Investigations and Oversight (May 2, 1994), said that "a simple definition of telemedicine is quite serviceable. Telemedicine is simply the use of telecommunications for medical diagnosis and patient care."[13] In 1995, while the broad definition of telemedicine continues to emphasize telecommunication technologies, the word "telemedicine" is increasingly being used as shorthand for "remote electronic clinical consultation."[11]

Telemedicine projects are found in most states. For example, Iowa has a medical information network to serve its rural areas. In Nebraska, the Synapse Health Resource Online project provides timely clinical and library resource information. Comprelink is a Cleveland, Ohio, project linking hospital physicians with referring physicians who do not have admitting privileges. HEALTHCON is an electronic bulletin board resource for health professionals in Montana. There are also projects in Texas; one is MedNet, which provides medical information and consultation by fax, and another is the Texas Telemedicine Project, which delivers medical services to a rural community through fully interactive two-way radio and TV communication.[12,14-17] One of the most advanced telemedicine systems, initiated in 1991 by the Medical College of Georgia, has proven so successful that the college plans to expand the network to cover the entire state.[18]

Telemedicine projects are under way in other parts of the world as well. In the Middle East, demonstration projects are under way to make global telemedicine affordable and practical. Norway, with many remote areas, is working on projects using telephone infrastructure for communication, and Finland has placed teleradiology capabilities in a large university hospital.[19-21]

There has been rapid growth of telecommunications, and consequently with telemedicine, during the early 1990s. Previously, telephone calls, telegrams, facsimile transmissions, and TV had been separate industries. Now that these technologies have been converted to digital formats, they are merging into a single market with a single commodity, the digital bandwidth.[12]

Recent studies cite the increasing use of the Internet, which is relatively inexpensive and highly accessible, for telemedicine.[22-26] A disadvantage of using existing infrastructure is the slow image transmission time; however, this problem can be reduced through image compression. For example, Joint Photographic Experts Group (JPEG) image transmission compresses images to 10% of original file size. The quality of x-rays, computed tomography scans, and ultrasound samples using JPEG compression were found to be indistinguishable from the original, uncompressed images.[27] A public digital telephone network also has been used to send images from the radiology department to the home of an on-call radiologist during off-peak hours, thus speeding up the response time while eliminating the need for the radiologist to return to the hospital.[19]

For the transmission of x-ray images, personal computers can be used in place of conventional, more expensive teleradiology imaging technology. Radiologists compared PC teleradiology images, conventional teleradiology images, and the original films and judged them to be similar in quality; however, variability in their diagnoses indicated that the teleradiology images yielded somewhat more reliable results than did the PC images. As PC technology improves, it is likely that inexpensive teleradiology will eventually be achieved using PCs, as compared to conventional teleradiology systems, which are from 15 to 20 times more expensive.[28] Commercial software packages also have been shown to be practical for telemedicine.[29]

The military also is taking an active role in the development of telemedicine applications. The Medical Diagnostic Imaging Support program, a four-year project to install Picture Archival and Communication Systems (PACS) in Army and Air Force treatment facilities, is already under way.[30] The Navy Telemedicine Initiative[31] is defined in terms of three types of emerging technology: videoteleconferencing (VTC), which provides two-way, real-time full motion video and audio for consultation and education; teleradiology, which consists of filmless radiology; and still image systems, which include photo-quality hard image transmissions. An example of the Navy's efforts is a teleradiology project which is already operating between Zagreb, Croatia, and the Naval Medical Center, Bethesda, Maryland. The Navy Initiative stresses the importance of standardization of technology and solid evaluation methods. On September 1, 1994, the Assistant Secretary of Defense for Health Affairs established the Department of Defense (DoD) Telemedicine Test Bed, a tri-service effort that will manage rapidly advancing digital communication technologies with military medical applications.[30]

With all of the equipment that is available, ranging from inexpensive telephone, Internet and e-mail, to expensive teleradiology and two-way teleconferencing video transmissions, it is important to fit the equipment to the medical situation. If a telephone consultation achieves its purpose, or if long transmission times are acceptable, it is unnecessary to invest in more expensive equipment. However, if two-way, real-time video communication is required to provide adequate medical care, then the investment is justified.

The primary objective of the present study was to demonstrate a methodology for evaluating the relative value of telecommunication technologies for making diagnosis and treatment decisions in Navy shipboard environments. Application of this methodology is used to evaluate the potential benefit of 15 available technologies, and information is provided that can be used to allocate limited resources.

Method

To determine the utility of various telemedical technologies for the diagnosis and treatment of common shipboard ailments, the 15 technologies shown in Table 1 were rated by 25 Independent Duty Corpsmen (IDCs) with experience aboard Navy surface ships. The IDCs rated the technologies on a 5-point scale with respect to the 28 patient conditions listed in Table 2. Each IDC was asked to complete the 57 items: the first 25 elicited ratings of the technologies for routine diagnostic decisions, seven elicited ratings of the technology for acute diagnostic decisions, and the final 25 elicited ratings of the technologies for treatment decisions.

TABLE 1. — TELECOMMUNICATION TECHNOLOGIES

TECHNOLOGY	*DEFINITION*
1. Fax	A facsimile machine, which transmits text as comments or demographic information accompanying an x-ray.
2. E-mail	Electronic mail, used to reproduce written text such as medical histories or descriptions of signs and symptoms.
3. Phone	The telephone, used for two-way voice communications allowing direct discussion between consulting parties.
4. Speakerphone	A speaker telephone that allows several parties to hear and participate in the conversation.
5. Radiophone	A radio telephone, used for two-way voice communications via the communication system of the ship.
The following medical equipment and protocols are used *in conjunction with* the telecommunication technologies above but have been treated as separate technologies for purposes of this study.	
6. Oscilloscope	The oscilloscope, used to monitor continuous electrophysiological information (EEG, ECG).
7. Stethoscope	An electronic stethoscope, used to amplify and transmit heart tones.
8. Sphygmomanometer	A sphygmomanometer is a blood pressure gauge which continuously displays systolic and diastolic pressures.
9. Slides	Full color, high resolution images of histology or cytology slides which can be transmitted directly from the microscope to the consultant's monitor.
10. Pics	"Pics" are pictures or body still images.
11. Otoscope	The otoscope is a device used to view interior ear canal.
12. Ophthalmoscope	An ophthalmoscope, used to examine a eye injuries or diseases.
13. Video	One-way video of the patient, sent to a consultant for diagnoses in which motion is a critical factor.
14. X-ray	Radiology images, digitized by scanning or captured directly in digital form and transmitted to a radiologist for consultation.
15. Dental X-ray	Dental radiology images that can be scanned and transmitted.

TABLE 2.— INCIDENCE RATES OF DIAGNOSES WHICH WERE CONSIDERED BY SUBJECT MATTER EXPERTS

DIAGNOSIS	*RATE**	*DIAGNOSIS*	*RATE**
Acute upper respiratory infection	.818	Disorders of urethra/urinary tract	.204
Back disorders	.540	Contact dermatitis/other eczema	.191
Dental examination	.488	Disorders of external ear	.184
Streptococcal sore throat & scarlatina	.395	Injury of eye	.180
Viral infection	.349	Acute sinusitis	.167
Cardiovascular/respiratory screening	.278	Gastritis/duodenitis	.162
Neoplasms screen (Pap/pelvic)	.260	Sprain/Strain of back/neck	.155
Disease due to viruses (chlamydia)	.239	Disease of sebaceous glands	.153
Soft tissue injury/musculoskeletal trauma	.235	Internal derangement of knee	.149
Noninfective gastroenteritis/colitis	.235	Candidiasis	.136
Acute pharyngitis	.222	Dermatophytosis	.134
Sprains/Strains of ankle/feet	.211	Phlebitis or thrombophlebitis	.011
Effects of external cause (motion sickness)	.209	Viral hepatitis	.010
Diseases of hair/hair follicle	.208	Mental or behavioral problems	.010

* Incidence per 1000 persons per day.

To control for the incidence of the different patient conditions, responses were weighted by the incidence per 1,000 persons per day. Incidence rates, also shown in Table 2, were based on data collected from 2,725 crew members (27 percent female) aboard four destroyer tenders and one repair ship during a one-month period.[32]

Before using the ratings to evaluate the various technologies, intraclass correlations were computed to assess the degree of agreement among raters for each question. This computation is a ratio of the variation among ratings that is a result of the judged value of the technologies being rated divided by the total variation; in other words, it is the proportion of variation due to the agreement among the raters on the value of the various technologies. The intraclass correlation for each item is shown in Table 3. Those items with a value below .25 were considered to have insufficient agreement among raters to be used in further analyses. As shown in Table 4, of the technologies rated, 15 had poor rater agreement for both diagnostic and treatment decisions, possibly because diagnosing or treating the patient condition being rated would not be improved by the various technologies, hence the lack of agreement. Four patient conditions, however, had reliable ratings for acute diagnostic and treatment decisions, and for six more the benefit for treatment decisions was rated reliably. Finally, the technologies rated two conditions reliably for diagnostic decisions, but no data were obtained regarding treatment decisions.

For the three conditions for which information technology was found to be beneficial for both treatment and diagnostic decisions, consistency of the ratings obtained can be determined by comparing ratings of the diagnostic value with ratings of the treatment value of technologies. Figures 1 - 4 show these comparisons for the patient conditions that had reliable ratings of diagnostic and treatment value. These figures show that the judged value of the technologies tend to vary depending upon the patient's condition, but, as expected, diagnostic and treatment ratings

were consistent within patient conditions. Therefore, when a patient presents with cardiology or respiratory problems, the transmission of x-ray and stethoscope information is the desired technology; when the patient has dental problems, dental x-rays are needed; and when ankle sprains and strains are encountered, the ability to transmit x-rays is required. In addition, there is consistency in the pattern of rating for ankle sprain/strain injuries and soft tissue injuries, where

TABLE 3.— RELIABILITY* OF TECHNOLOGY RATINGS BY PATIENT CONDITION

Patient Condition	*Diagnosis Acute/Routine**	*Treatment*
Acute upper respiratory infection	.21	.26
Back disorders	.16	.47
Dental examination	.27/.17	.34
Streptococcal sore throat & scalatina	.12	.13
Viral infection	.12	.11
Cardiovascular/respiratory screening	.27/.38	.42
Neoplasms screen (Pap/pelvic)	.23	.33
Disease due to viruses (chlamydia)	.17	.30
Soft tissue injury/musculoskeletal trauma	.34/.42	.48
Noninfective gastroenteritis/colitis	.19	.18
Acute pharyngitis	.08	.14
Sprains/Strains of ankle/feet	.27/.33	.35
Effects of external cause (motion sickness)	.12	.01
Diseases of hair/hair follicle	.06	.05
Disorders of urethra/urinary tract	.15	.17
Contact dermatitis/other eczema	.06	.02
Disorders of external ear	.14	.14
Injury of eye	.21	.33
Acute sinusitis	.08	.17
Gastritis/duodenitis	.17	.14
Sprain/Strain of back/neck	.21	.16
Disease of sebaceous glands	--	--
Internal derangement of knee	.16	.27
Candidiasis	.19	.19
Dermatophytosis	.09	.13
Phlebitis or thrombophlebitis	.27/---	
Viral hepatitis	.17/---	
Mental or behavioral problems	.47/---	

* As determined by intraclass correlations.

** "Acute" describes emergency situations while "routine" describes non-emergency situations.

TABLE 4.— CLASSIFICATION OF DIAGNOSES ACCORDING TO DEGREE OF RATER AGREEMENT

	Degree of Rater Agreement					
	Acute Diagnostic Decisions*		*Routine* Diagnostic Decisions*		*Treatment Decisions*	
Patient Condition	*Good*	*Poor*	*Good*	*Poor*	*Good*	*Poor*
Acute upper respiratory infection	n/a			✓	✓	
Back disorders	n/a			✓	✓	
Dental examination	✓			✓	✓	
Streptococcal sore throat & scalatina	n/a			✓		✓
Viral infection	n/a			✓		✓
Cardiovascular/respiratory screening	✓		✓		✓	
Neoplasms screen (Pap/pelvic)	n/a			✓	✓	
Disease due to viruses (chlamydia)	n/a			✓	✓	
Soft tissue inj./musculoskeletal trauma	✓		✓		✓	
Noninfective gastroenteritis/colitis	n/a			✓		✓
Acute pharyngitis	n/a			✓		✓
Sprains/Strains of ankle/feet	✓		✓		✓	
Effects of external cause-motion sickness	n/a			✓		✓
Diseases of hair/hair follicle	n/a			✓		✓
Disorders of urethra/urinary tract	n/a			✓		✓
Contact dermatitis/other eczema	n/a			✓		✓
Disorders of external ear	n/a			✓		✓
Injury of eye	n/a			✓	✓	
Acute sinusitis	n/a			✓		✓
Gastritis/duodenitis	n/a			✓		✓
Sprain/Strain of back/neck	n/a			✓		✓
Disease of sebaceous glands	n/a			✓		✓
Internal derangement of knee	n/a			✓	✓	
Candidiasis	n/a			✓		✓
Dermatophytosis	n/a			✓		✓
Phlebitis or thrombophlebitis	✓		n/a		n/a	
Viral hepatitis		✓	n/a		n/a	
Mental or behavioral problems	✓		n/a		n/a	

* "Acute" describes emergency situations while "routine" describes non-emergency situations.

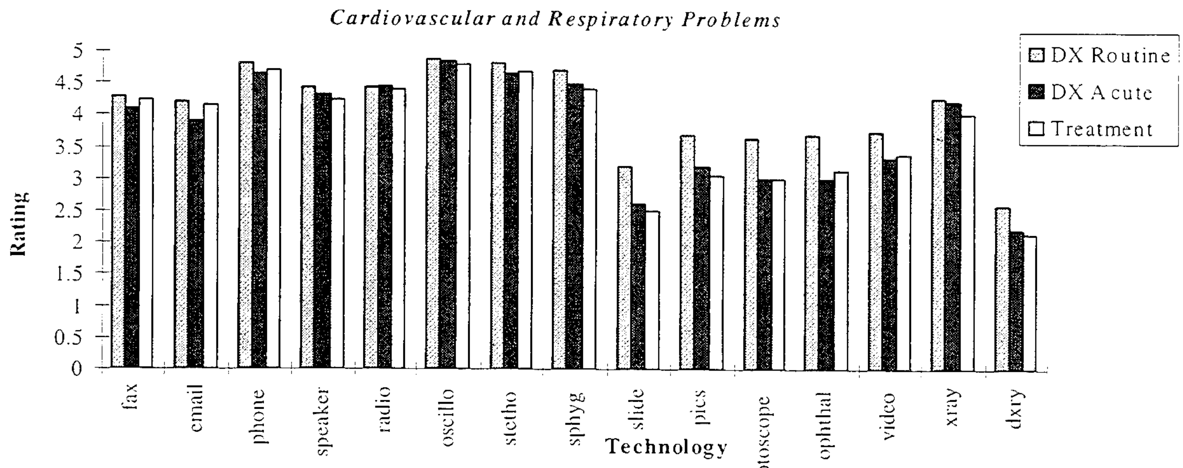

Fig. 1—Ratings for technology categories with respect to acute diagnostic, routine diagnostic, and treatment decisions for patients with cardiovascular and respiratory problems.

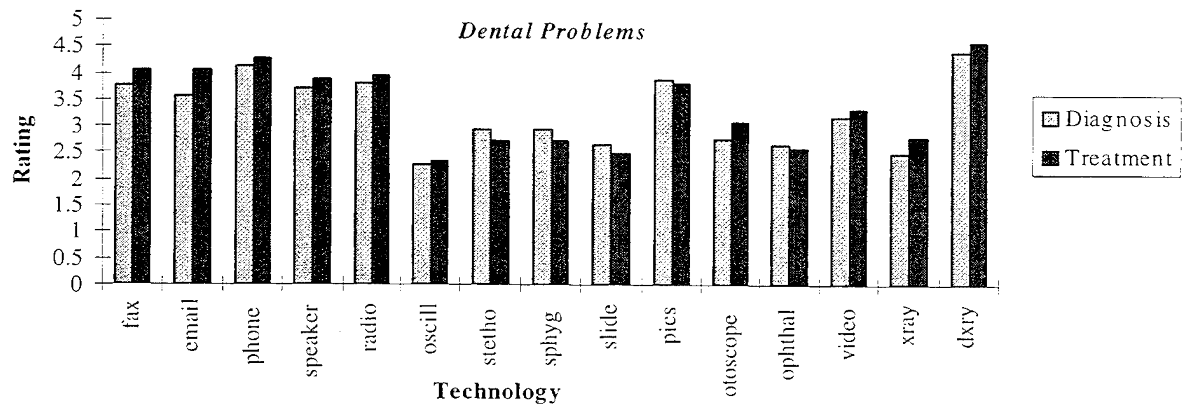

Fig. 2—Ratings for technology categories with respect to diagnostic and treatment decisions for patients with dental problems.

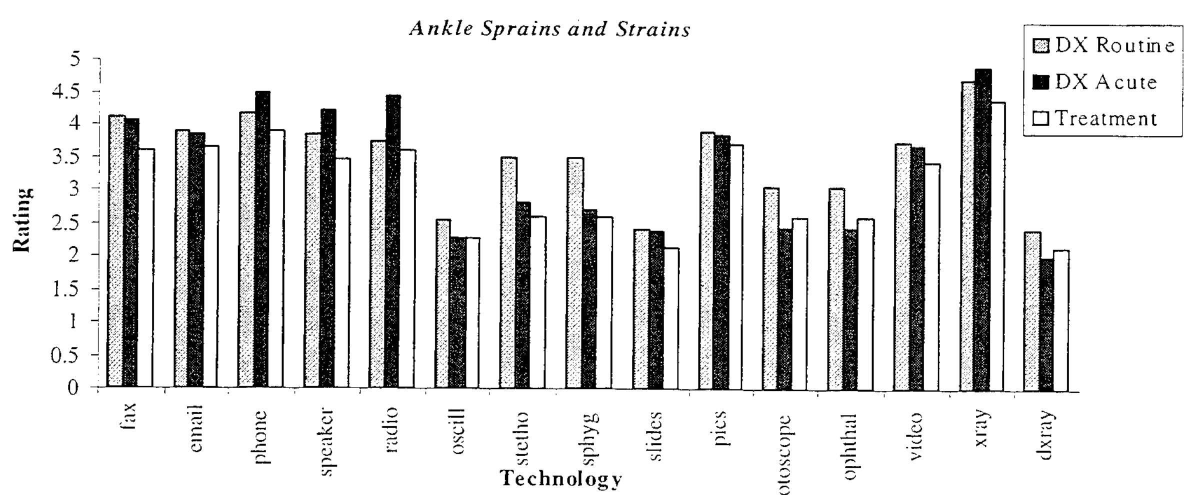

Fig. 3—Ratings for technology categories with respect to acute diagnostic, routine diagnostic, and treatment decisions for patients with ankle sprains and strains.

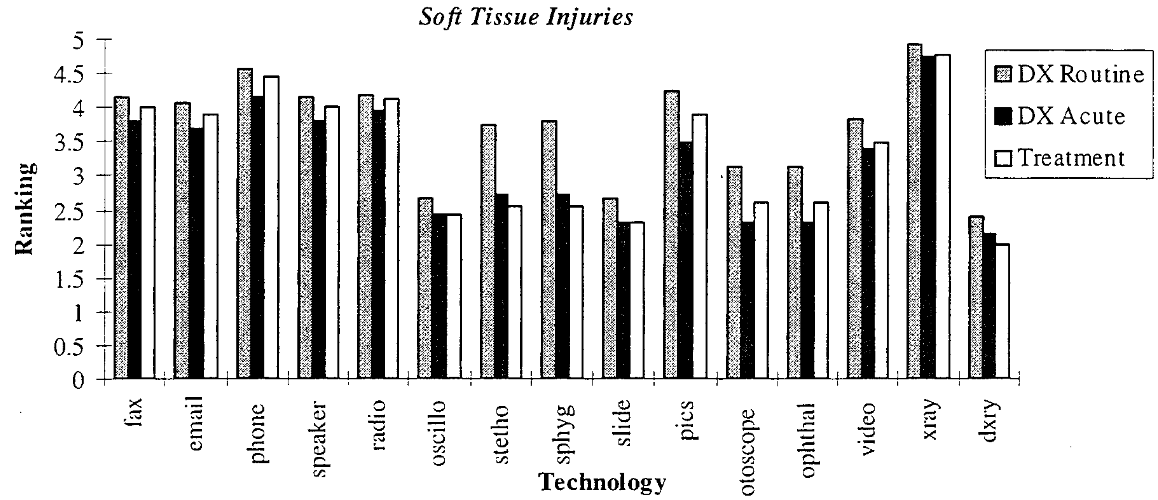

Fig. 4—Ratings for technology categories with respect to acute diagnostic, routine diagnostic, and treatment decisions for patients with soft tissue injuries.

technologies that would help with the diagnosis and treatment of ankle sprains and strains are seen to be of benefit for diagnosis and treatment of soft tissue injuries. Additionally, Figure 5 shows that treatments for back disorders and derangement of the knee, and diagnosis of phlebitis appear to benefit from these same technologies. For Pap/pelvic examinations and chlamydia infection, the perceived value of transmitting slide images is evident in Figure 6. Finally, the data graphed in Figure 7 indicate that diagnosis of mental disorders and treatment of eye injuries and upper respiratory inspections each benefit from technologies specific to the patient condition. Table 5

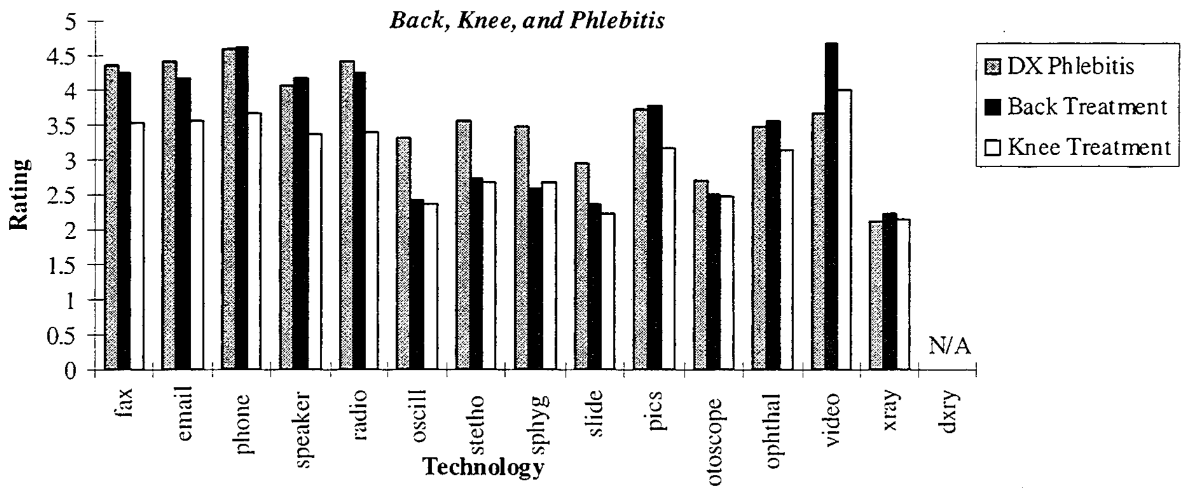

Fig. 5—Ratings for technology categories with respect to treatment decisions for patients with back disorders and derangement of the knee, and diagnostic decisions for patients with phlebitis.

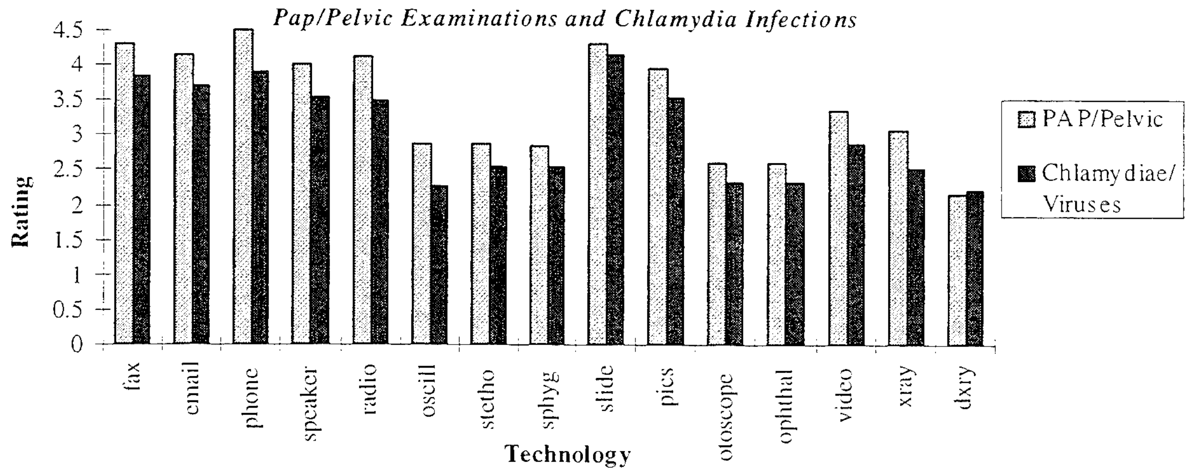

Fig. 6—Ratings for technology categories with respect to treatment decisions for patients presenting for Pap/pelvic examinations and chlamydia infections.

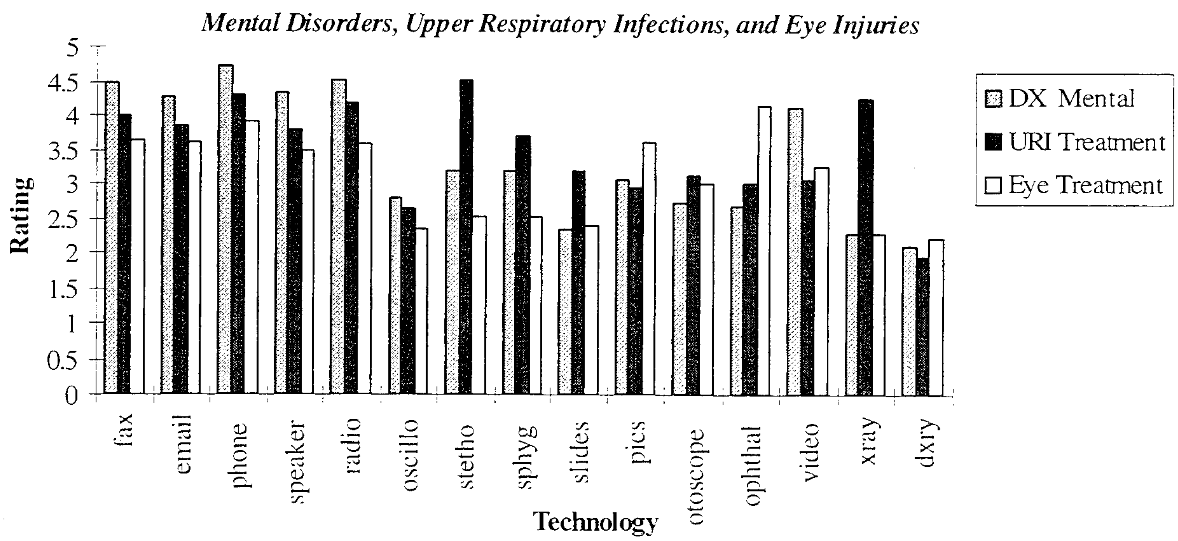

Fig. 7—Ratings for technology categories with respect to diagnostic decisions for mental disorders, upper respiratory infections, and eye injuries.

provides a summary of the technologies judged to be of value for the various patient conditions. It is interesting to note that, whether making a diagnostic or treatment decision, the least sophisticated technology is the most desired (i.e., telephone, fax). Also, the greater utility of teleconferencing for mental disorders as opposed to other disorders is notable.

TABLE 5. — MOST BENEFICIAL TECHNOLOGIES FOR A GIVEN PATIENT CONDITION

PATIENT CONDITION	*TECHNOLOGY*
All conditions	Fax, e-mail, phone, speakerphone, radiophone
Cardiovascular/respiratory screening	Otoscope, stethoscope, sphygmomanometer
Upper respiratory infection	Stethoscope, sphygmomanometer
Pap/pelvic neoplasm screen, chlamydia	Slides
Back disorders, soft tissue injury, internal derangement of knee, phlebitis	Pics, x-ray
Eye injury	Ophthalmoscope
Mental or behavioral problems	Video
Dental examination	Dental x-ray

To compare the judged value of these technologies with respect to a typical patient load, as opposed to a given patient condition, the mean technology rating for each item was weighted by the incidence rate per 1,000 crew members per day (these values are shown in Table 2). Figure 8 shows the sum of these weighted ratings for each technology as a combination of the

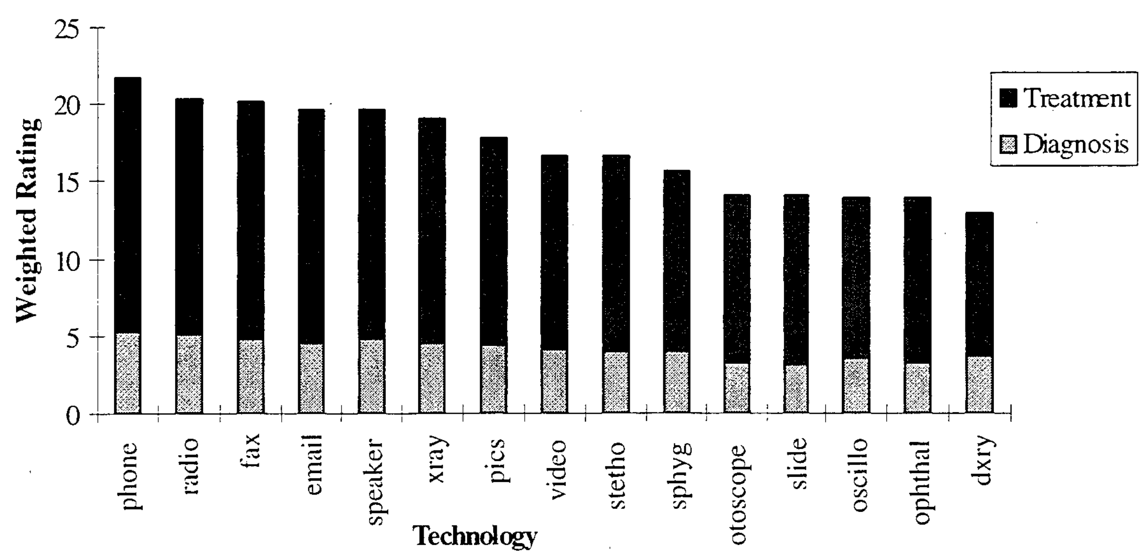

Fig. 8—The technology categories ranked by ratings weighted by patient condition incident rates.

judged benefit for diagnostic decisions and the judged benefit for a treatment decision. Again, it can be seen that those technologies that are most beneficial for diagnosis tend to be the most beneficial for treatment. Also, it is apparent that the various technologies are viewed as being more useful for making a treatment decision than for making a diagnostic decision.

Discussion

This study has provided information about the perceived relative benefit of selected telemedicine technologies for diagnosing and treating patients aboard U.S. Navy ships. Raters consistently judged telemedicine as more beneficial for acute than for routine conditions, both for diagnostic and treatment decisions, and they expressed preference for basic equipment such as telephones and fax machines. This preference, however, could result from "hierarchical necessity" in that sophisticated transmissions such as digitized x-rays are of little use without basic communication. Furthermore, the findings of this preliminary study were based on the most frequently-occurring patient conditions; other factors, such as criticality of a condition, or efficicacy of telemedicine in treating a given condition, should be considered in future research. In summary, then, health-care providers on Navy ships, according to this study, want to be able to consult with physicians at other treatment facilities in emergency situations.

Before such technologies are implemented, a number of factors, such as cost, security, and command and control issues, must be considered. On one level, unsecured telecommunication transmissions could compromise the security of the ship's mission through uncontrolled electronic emissions, and on another level, the same transmissions could reveal patient data to people who are not bound by the tradition and ethics of the medical profession. Questions of privacy, confidentiality, and security of patient data must be answered for telemedicine environments.[33,34]

The shipboard environment, because it is a self-contained system, has additional problems to solve when utilizing telemedicine technology.[33,34] Command and control is a major issue aboard deployed ships; in contrast to civilian facilities where the sole function is medical care, a shipboard medical department operates in support of the mission.[35] Since medical communications must be coordinated hierarchically with the ship's overall operational objectives, they may not receive the highest priority. Also, obtaining sufficient bandwidth for effective telemedicine communication could be problematic because the ship's total bandwidth is limited and also must support tactical communications. The issue of physical space is important as well; every piece of equipment aboard ship must be used effectively and efficiently.

Navy telemedicine can be an effective tool that provides health-care to patients, and it can be of particular benefit to health-care providers in remote locations, providing consultation capability for medical emergencies. Careful planning, appropriate personnel training, and suitable testing and evaluation procedures are the keys to achieving these benefits.

REFERENCES

1. Wittson CL, Affleck DC, Johnson V: Two-way television group therapy. *Mental Hospital*, Nov. 1961, 12:22-23.

2. Borowski W: Medical television: prescription for progress. *JAMA*, Oct. 6, 1993, 270(13).

3. Fiechs M: Provider attitudes toward STARPAHC, a telemedicine project on the Papago Indian Reservation. *Medical Care*, Jan. 1979, 17:59-68.

4. Dunn E, Conrath D, Action H, Higgins C, Math M, Bain H: Telemedicine links in Sioux lookout with doctors in Toronto. *Canadian Medical Association Journal*, 1980, 22:484-7.

5. Higgins CA, Conrath DW, Dunn EV: Provider acceptance of telemedicine systems in remote areas of Canada. *Journal of Family Practice*, Feb., 1984, 18(2):285-9.

6. Brauer GW: Telehealth: the delayed revolution in health care. *Medical Progress Technology*, 1992, 18:151-163.

7. Rayman RB: Telemedicine: military applications. *Aviation, Space, and Environmental Medicine*, Feb. 1992.

8. Gunby P: Satellite hookup links major U.S. military hospital with Army physicians in Mogadishu, Somalia. *JAMA*, Apr. 7, 1993, 269(13):1606.

9. Nice DS: U.S. Navy medical communications and evacuations at sea. *Military Medicine*, Sept. 1987, 152(9):446-451.

10. Stevens I, Zekan C: Remote Medical Diagnosis System (RMDS): utilization study. Technical Report 700, August 1989, Naval Ocean Systems Center, San Diego, California.

11. Perednia DA, Allen A: Telemedicine technology and clinical applications. *JAMA*, Feb. 1995, 273(6):483-488.

12. Preston J, Brown FW, Hartley B: Using telemedicine to improve health care in distant areas. *Hospital and Community Psychiatry*, Jan. 1992, 43(1):25-31.

13. Lindberg DAB, Director. National Library of Medicine. Testimony before the House Science, Space and Technology Committee Subcommittee on Investigations and Oversight, May 2, 1994.

14. Wagner G: The Iowa Medical Information Network: a concept. *Journal of Medical Systems*, 1992, 16(2/3):73-85.

15. Meter RK: Synapse Health Resources Online. *Journal of Medical Systems*, 1992, 16(2/3):91-94.

16. Pomieko EC: Comprelink--a physician to physician communication network. *Journal of Medical Systems*, 1992, 16(2/3):87-90.

17. Flaherty RJ: HEALTHCON - an innovative resource for Montana health professionals. *Journal of Medical Systems*, 1992, 16(2/3):71-72.

18. DeBakey ME: Telemedicine has now come of age. *Telemedicine Journal*, 1995, 1(1):3-4.

19. Nilsson M, Sjoberg S, Gladh T, Larsson R, Troedsson U: Digital image communication using a public digital telephone network. *Computer Methods & Programs in Biomedicine*, May, 1994, 43(1-2):145-9.

20. Goldberg MA, Sharif HS, Rosenthal DI, Black-Shaffer S, Flote TJ, Colvin RB, Thrall JH: Making global telemedicine practical and affordable: demonstrations from the Middle East. *American Journal of Roentgenology*, Dec. 1994, 163(6):1495-500

21. Kormano J, Kallio T, Heinila J: Teleradiology in Turku University Hospital--diagnostic and clinical applications. *Computer Methods & Programs in Biomedicine*, May 1994, 43(1-2):125-8.

22. Richardson ML: A World Wide Web radiology teaching file server on the Internet. *American Journal of Roentgenology*, Feb. 1995, 164(2):489-91.

23. Kleeberg P: Medical uses of the Internet. *Journal of Medical Systems*, 1993, 17(6).

24. Galvin JR, D'Allessandro MP, Kurihara Y, Erkonen WE, Knutson TA, Lacey DL: Distributing an electronic thoracic imaging teaching file using the Internet, Mosaic, and personal computers. *American Journal of Roentgenology*, Feb. 1995, 164(2):489-91

25. McEnery KW: The Internet, World Wide Web and Mosaic: an overview. *American Journal of Roentgenology*, Feb. 1995, 164(2):469-73.

26. Hostetler S., Ed. Software allows remote consultations to be performed via Internet. *Telemedicine*, May 1994, 2(5):1,6.

27. Yamamoto LG: Using JPEG image compression to facilitate telemedicine. *American Journal of Emerging Medicine*, Jan. 1995, 13(1):55-7.

28. Yamamoto LG, DiMauro R, Long DC: Personal computer teleradiology: comparing image quality of lateral cervical spine radiographs with conventional teleradiology. *American Journal of Emergency Medicine*, Jul. 1993, 11(4):384-9.

29. Heinila J, Yliaho, Ahonen J, Viitanen J, Kormano M: X window system based user interface in radiology. *Computer Methods & Programs in Biomedicine,* May 1994, 43(1-2):129-38.

30. Walgren H: Evolution of teleradiology in the defense medical establishment. *Telemedicine Test Bed*, World Wide Web http://ftdetrick-matmoweb.army. Jan. 25, 1995.

31. Fisher DH: Navy Telemedicine Initiative. Letter, Commanding Officer, Naval Medical Information Management Center. June 1994.

32. Nice DH, Hilton SM: Determinants of the delegation of health care aboard ships with women assigned. Report No. 89-23, Naval Health Research Center, 1989, San Diego, California.

33. Lincoln TL: Traveling the new information highway. *JAMA*, June 22/29, 1994, 271(24).

34. Gostin LO, Turek-Brezina J, Powers M, Kozloff R, Faden R, Steinhower DD: Privacy and security of personal information in a new health care system. *JAMA*, 1993, 270:2487-2494.

35. Department of Defense: Medical Readiness Strategic Plan 2001. MRSP 2001, March 20, 1995.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 31, 1995

3. REPORT TYPE AND DATE COVERED
Final - 10/1-12/31/95

4. TITLE AND SUBTITLE
Preliminary Evaluation of Selected Telecommunications Technologies for Medical Care Aboard Navy Ships

5. FUNDING NUMBERS
Program Element: 63706N
Work Unit Number:
M0096.001-6426

6. AUTHOR(S)
Eleanor Gauker, William Pugh, Dianna Pearsall

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Health Research Center
P. O. Box 85122
San Diego, CA 92186-5122

8. PERFORMING ORGANIZATION
Report No. 95-32

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Medical Research and Development Command
National Naval Medical Center
Building 1, Tower 2
Bethesda, MD 20889-5044

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study demonstrates a method for ranking available telecommunication technologies in terms of relative perceived benefit. Fifteen technologies were rated on a 5-point Likert scale by 25 Independent Duty Corpsmen (IDCs) with experience aboard Navy surface ships. The IDCs rated the utility of the technologies with respect to 28 patient conditions. Each IDC was asked to complete 57 items. 25 items referred to routine diagnostic decisions, 7 involved acute diagnostic situations, and 25 concerned treatment decisions. Intraclass correlations, computed for each question, determined the degree of agreement among raters. Four patient conditions had reliable ratings for both acute diagnostic and treatment decisions, six other patient conditions showed acceptable reliability for treatment decisions, and three conditions were rated reliably for routine diagnostic decisions. Although complex technologies, such as the transmission of x-ray images, were rated as beneficial for diagnosing and treating some disorders (e.g., sprains and strains) it was found that fax machines and e-mail were more beneficial overall. The analysis showed that those technologies rated most beneficial for diagnosis also tended to be most beneficial for treatment. It is concluded that Navy telemedicine can be an effective tool when careful planning, suitable personnel training, and appropriate testing and evaluation procedures are in place.

14. SUBJECT TERMS
Telecommunication, Telemedicine, Naval Medical Care,

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102